program, he mentioned the recent establishment of a child-guidance clinic in Niagara Falls, New York, under the terms of the will of the late Mrs. Martha H. Beeman of that city, who left a fund of $400,000 for child welfare. After months of study of the various ways in which this money might be used, it was decided by the executor to devote the entire fund to child-guidance work. The plans for the clinic have not only been worked out under the direction of members of the staff of The National Committee for Mental Hygiene but that Committee, under the deed of trust, is to serve in a continuing capacity as special adviser on plans, policies and personnel.

Mr. Beers closed his talk with a brief description of the National Committee's activities, of the plans for the First International Congress on Mental Hygiene, which is to be held in Washington, D. C., from May 5th to 10th, 1930, and of The American Foundation for Mental Hygiene, recently incorporated by a group of officers of the National Committee for the purpose of serving as custodian and administrator of gifts and bequests for use in financing mental hygiene work and agencies in all parts of the field.

THE INVOLUNTARY NERVOUS SYSTEM *

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I come to you from the oldest hospital in the English speaking world; six years ago we celebrated our 800th anniversary. In a sense our hospital is the direct grandchild of the original temple of Aesculapius at Epidauros, whence the Romans brought the statue of the god when they founded a temple of healing on Tiber Island. In Christian times this temple became the hospital and the Church of San Bartolomeo, and it was while a patient here that Rahere conceived the idea of erecting the Hospital

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and Church of St. Bartholomew's in London. The Hospital and Church still stand in Rome on Tiber Island; the Church of St. Bartholomew the Great was one of the five churches that escaped the great fire of London, and in the adjoining hospital the work of healing has not ceased these eight hundred years.

It is interesting to recall that the main features in the cult of Aesculapius were cleanliness, fresh air, psychological explanation, suggestion and dream analysis, so that the medicine of the 20th century has shown a striking tendency to return to the original cult.

As a representative of that grandchild of the original temple it is a great pleasure to me to come to this dignified and beautiful new temple, dedicated to Aesculapius, where the traditional and the progressive elements of medicine are so happily blended.

When I was invited by this Academy to participate in your Graduate Fortnight I naturally appreciated the honour very highly, but when I saw the list of distinguished men who were also to lecture I began to wonder what contribution I had to offer which they were not in a much better position to make than I. Then remembering that the topic of the Involuntary Nervous System was allotted to me, I reflected that there could not be many physicians still practising who had actually worked under both Gaskell and Langley at the time they were engaged in their researches on this subject, and who had had the opportunity of seeing the results gradually unfolded. It therefore occurred to me that it might be of interest if I gave you my impressions of those researches in the making, before turning to their subsequent clinical applications. For they stamped themselves deeply on my mind as a young man, and have greatly influenced the subsequent trend of my clinical ideas.

Gaskell and Langley were two of the earliest group of distinguished men that Michael Foster gathered round him when he went to Cambridge. It is a curious and interesting fact that two such different characters should, starting from such different standpoints, have reached convergent and confirmatory results.

Gaskell was essentially a big man, alike in physique, personality and character. He poured out ideas with unstinted prodigality, often giving them to his pupils to develop and to take the credit for. He delighted in sweeping generalisations in which, though they were sometimes based on inadequate detail, he was guided aright by his philosophic insight.

Langley, small and trim with a steely blue eye which had a strangely hypnotic effect on many people, excelled in exact, meticulous, careful detail, preferring to work behind closed doors until he was sure of his results and then demonstrating them with a cool, incisive precision.

Gaskell had worked with Ludwig and had been primarily interested in the cardio-vascular system. His studies on the rhythm of the heart and on vaso-dilatation led him to study the vago-sympathetic trunk to the frog's heart and through that, the involuntary nervous system in general.

Langley had worked with Heidenhain and was engrossed in the histology of secretion, particularly the secretory granules as the forerunner of the characteristic secretion of the gland. This led him to the study of the influence of the chorda tympani and the sympathetic on the secretion of the submaxillary glands. He became intrigued by the "paralytic secretion" which follows section of the chorda tympani, but seemed to reach a dead end here, until in conjunction with Dickinson he discovered the paralysing effect of nicotine on the pre-ganglionic sympathetic nerve endings. He was quick to grasp the opportunity this gave him to unravel in detail the distribution of the sympathetic nerve fibres. Patiently, unremittingly he laboured for years till the whole plan was clear.

But it is always the great explorer in unknown territory who claims our allegiance and fascinates our imagination. To you the names of Columbus, Amerigo Vespucci and Cabot mean more than that of a skilled investigator in the latest geographical survey of your continent. And so to me the great sweep of Gaskell's mental telescope was more stirring than the splendid accuracy of Langley's mental microscope. Moreover, Gaskell's work should claim our first attention since in point of time it came first.

To read an account of the sympathetic nervous system before Gaskell is like reading an account of the circulation before Harvey. Both of these great observers reduced chaos to order. Looking back it is difficult to realise that before Gaskell the actual course of the impulses in the cervical sympathetic was not understood. And the starting point, as I have already hinted, was the recognition that the vagus nerve to the frog's heart was really a combined vago-sympathetic trunk; the sympathetic part of which joined the other at the vagus ganglion. It therefore appeared that the impulses in the cervical sympathetic ran upwards into the neck, *i.e.,* towards and not away from the brain, and he soon traced the outflow of the cardiac fibres to the anterior root of the 3rd spinal nerve, whence they passed by the white ramus communicans to the sympathetic chain.

Whereas previous observers had obtained divergent results from stimulation of what he showed was a mixed nerve trunk, he found that if the vagus and sympathetic were stimulated before they had united the results were constant, the vagus producing inhibition and the sympathetic acceleration. He also showed that this inhibition was essentially an anabolic process, since the subsequent heart beats were more powerful and capable of overcoming a previous heartblock, while the acceleration was essentially a katabolic process, since the subsequent beats were feebler and a partial heartblock became more complete. This view of inhibition as protective and conservative in character is one which has had an important influence in physiology and psychology alike. I sometimes wonder whether my fellow-student of those days, Prof. Wm. McDougall, did not have his interest in inhibition originally aroused by Gaskell's work. At any rate. it was the subject of one of his earliest papers.

Coming to the mammal, Gaskell found a closely similar origin for the inhibitory and accelerator fibres to the heart, though they remained separate throughout their subsequent course. The sympathetic or accelerator fibres were shown to spring from the 2nd and 3rd thoracic anterior nerve roots. Cutting sections of these nerve roots central to the white ramus he found that they contained two different types of fibres, markedly differing in calibre, and that all the fibres of small calibre passed into the white rami, while the anterior root beyond this point contained only large fibres. But a section of a cervical root which had no white ramus had only large fibres. His mind quickly grasped the significance of this—somatic nerve fibres are of large calibre, visceral nerve fibres are of small. Here to his hand was a method of determining the general plan of the involuntary nervous system. The weapon with which this observation supplied him was a simple one, but what a tremendous use the mind that wielded that weapon proceeded to make of it. Applying this test, he showed that fibres of small calibre left the spinal cord by every anterior root between the 2nd thoracic and the 2nd lumbar. Above and below this came a break where the great nerve plexuses to the limbs originated; here only large fibres were to be seen. But above the brachial plexus and below the lumbar plexus small fibres were again to be seen, above in the vagus and certain other cranial nerves, below in what we now call the pelvic visceral nerve. All these small fibres had visceral function, though evidently different in function to the thoracic lumbar outflow; indeed when they were distributed to the same structures the functions of the two were directly antagonistic.

Thus the first great generalisations as to the involuntary nervous system were reached. (1) It was shown to consist of an outflow of small medullated nerves occurring—(a) From all the anterior roots between the two great limb plexuses—this constituting the true sympathetic outflow. (b) Above and below the limb plexuses—this constituting what is now usually called the parasympathetic. (2) Whatever the destination of these fibres, their origin was always restricted to these areas. (3) Whenever sympathetic and parasympathetic fibres supplied the same structure their effects were antagonistic.

Turning to the consideration of the cells from which these fibres originated he concluded by a process of deduction, and without the histological aids subsequently devised by Golgi and Ramon y Cajal, that the sympathetic fibres sprang from the cells in the lateral horn of the spinal grey matter, and that the parasympathetic fibres came from cells in a closely analogous position. The complete segmental nerve was not composed of two but of three parts, afferent, efferent and visceral, but in the elaboration of the brain the segments had undergone fusion and readjustment, so that the arrangement was more complicated. This led him to the recognition of the existence of afferent visceral nerves. Edgeworth, working under him, traced some of the few fibres of larger calibre in the white rami to the Pacinian corpuscles in the cat's mesentery, obviously sensory structures. He therefore extended his conception of a complete segmental nerve thus (1) a somatic part containing efferent and afferent fibres, and, (2) a visceral part also containing efferent and afferent fibres.

The development of highly organised limbs led to the corresponding parts of the spinal cord having to devote themselves exclusively to somatic functions, such visceral fibres as they needed having to be supplied from other regions of the central nervous system. The vertebrate body is fundamentally a tube within a tube, the inner tube being supplied by visceral, and the outer by somatic fibres.

This conception led him into a far more speculative field, the origin of the vertebrates. Many have deplored this diversion of his interest from a field in which he was supreme to one where he was at first relatively an amateur. It is not too much to say that morphologists actually resented his intrusions with revolutionary ideas into their preserves. It cannot be said that his views as to the origin of the vertebrates from an arthropod ancestor command general acceptance, but we cannot lightly neglect the mass of evidence he accumulated in favour of his theory during the remaining years of his life. At first strongly prejudiced against it by my training in the morphological traditions of Frank Balfour, Lord Balfour's brilliant brother, so early cut off, I have gradually become more favourably disposed to it, as it was found to anticipate subsequent anatomical discoveries, and to provide a reasonable explanation of the origin of the endocrine system, a system which was almost unknown when Gaskell first promulgated his theory.

This, I think, is about as far as we can profitably apply the historical method to Gaskell's work. The rest of it can be better treated as part of the more complete picture resulting from Langley's researches. It may seem to you that I have somewhat laboured several points of common knowledge, but I have done so in the belief that a more vivid impression can be derived from a study of the steps by which that knowledge was acquired.

Let us now turn to Langley. I should summarise his great contributions to the subject as (1) the proof that every sympathetic impulse has to pass first through a preganglionic medullated fibre and then through a post-ganglionic non-medullated fibre, (2) the discovery of pilomotor fibres which enabled the segmental distribution of visceral fibres to the skin to be demonstrated, (3) the generalisation as to the action of adrenalin in connection with the sympathetic. I will deal with each in turn.

Together with Dickinson he found that if he painted a solution of nicotine on a sympathetic ganglion certain fibres were paralysed and others were not. He soon realized that those which were thus affected were the ones which had their cell station within that ganglion, whereas the unaffected ones were merely passing through it. Patiently applying this method he proved that the small medullated fibres which left the spinal cord between the great limb plexuses to enter the sympathetic chain by way of the white rami might end in an arborisation around a cell either in a lateral ganglion on that chain, or collateral as in the solar plexus, or terminal as in the intestinal plexuses. This pre-ganglionic arborisation was the one which was paralysed by nicotine. From the ganglion cell a relay started, as a post-ganglionic non-medullated fibre, by which the impulse was distributed to its final destination. Thus every such impulse was transmitted through two and only two neurons; the first having its cell station in the lateral horn of the spinal cord and possessing a medullated axon, the second having its cell station in a sympathetic ganglion and possessing a non-medullated axon. Further, a pre-ganglionic portion could operate on a considerably larger number of post-ganglionic, in this way providing for a wide and rapid diffusion of stimuli. This anatomical plan also allowed of the distribution of sympathetic fibres to areas which had no outflow of such fibres of their own. It was known that while white rami communicantes were confined to the region between the second thoracic and the second lumbar nerves, grey rami were to be found at every nerve root. These latter, he was able to show, were post-ganglionic fibres running back from the sympathetic system to the spinal nerves, to be carried with them to the periphery. In this way every part of the body received its sympathetic quota, and the difficulty produced by the interposition of the limb plexuses was overcome. He introduced the term "made-up" spinal nerve, for the nerve which had shed its pre-ganglionic element and had received its post-ganglionic quota.

He found confirmation for these views in the distribution of the pilomotor fibres. It is well-known that certain animals have the power of erecting their hair or quills during fear or anger, and that our own condition of "goose skin" is a persistence of this, though its occurrence singularly fails now to make us either look or feel more alarming. Some of our reflexes, like some of our structures, are vestigial. It is further known that these pilomotor fibres are innervated by the sympathetic. Langley found that by stimulating a white ramus in a cat he produced an erection of the hairs over a considerable number of segmental areas, usually five or six. But if he stimulated a grey ramus, there was a more powerful erection over only one such area. In other words, the sympathetic ganglion acted as a distributing station by which an impulse coming down one pre-ganglionic fibre could be diffused over five or six post-ganglionic areas. Thus two things were proved—one that there is a strictly segmental distribution of visceral fibres to the skin, which overlap as far as their spinal origin is concerned, but not in their ultimate destination—the other that wide and rapid diffusion of visceral effects is ensured. It is practically certain that a similar plan is followed in the control of some other visceral functions.

And now as to adrenalin. When Schäfer and Oliver first discovered an active secretion in the medulla of the adrenals they showed that it raised blood pressure by vasoconstriction and accelerated the heart. Although ever since Addison's original account of the disease known by his name, the close anatomical association between the sympathetic and the adrenals had been realised, the full significance of Schäfer and Oliver's observation was not understood. Nor did Blüm's discovery that injections of adrenalin would excite glycosuria suggest it. It was not until T. R. Elliott had elaborately studied the effect of adrenalin on various structures that the way was made clear for Langley's generalisation—the effect of adrenalin on any part is the same as the stimulation of the sympathetic nerve to that part, and adrenalin has no effect on any tissue which has never had a sympathetic supply.

Note what follows from that generalisation. The adrenals are the one exception to the rule that pre-ganglionic fibres are not distributed direct to a muscle or a gland. And, to use a phrase often erroneously employed with tiresome reiteration, this really is an exception which proves the rule. For the chromaffin cells of the adrenal medulla are nervous in origin. Not only anatomically but phylogenetically, embryologically and functionally the adrenals and the sympathetic are in the closest association. Strictly speaking, in the adrenals the chromaffin cell represents the post-ganglionic element. The principle of wide diffusion of sympathetic impulses is here carried to a triumphant conclusion, for the lower neuron of a particular part of the sympathetic is transformed into a glandular structure whose secretion reproduces all the sympathetic effects when it is carried into the circulation.

I hope that by stating it in this way I can avoid the controversy as to the emergency action of adrenalin, though it must be obvious that my sympathies are with Cannon rather than with Stewart and Rogoff in that matter. But, in passing, I cannot refrain from pointing out that in the relationship of the hypothalamus, often regarded as the head ganglion of the sympathetic, to the pituitary gland, we have a similar example of an originally nervous structure acquiring a secretory function and being activated by the associated nervous tissues. I would call your attention to the recent Goulstonian Lectures, given by my former distinguished pupil Professor E. B. Verney, in which the position of the pituitary has been rehabilitated. In each of these endocrine glands we have a two-fold structure, one glandular throughout, the other primarily nervous but assuming secretory functions under the control of the involuntary nervous system.

And now let me return from this excursion into history to try and evaluate the biological position of the involuntary nervous system in the light of the researches I have detailed. When organisms were still of a lowly structure their life of internal relation was simple and could still be carried on by chemical mechanisms. But they required an "awareness" of their environment, a capacity to avoid danger and to seek food. Thus it happened that sensitive perceptive structures were first developed on the surface of their bodies. Nervous structures are ectodermal in origin, but the nerve cells soon tended to withdraw themselves into a more protected position. The migration of the cell in the lower sensory neuron from a sub-epithelial position to one close to the spinal cord is an example of this. The invagination of the neural tube in the vertebrate embryo is merely a developmental short cut to the same end. For the simplest reflex action we require a receptor neuron and an effector or excitor neuron. But in the primitive nerve network in which the cells of such neurons reside a third type of cell develops, the adjustor or connector neuron which mediates between the two. This constitutes the first germ of a central nervous system, and we know that it is by the increase of the number of such association cells, as they are more usually called, that the increasing complexity of the central nervous system declares itself. Now there is a striking difference between the position of the connector units in the somatic and visceral nerves respectively. In the somatic nerves the immediate connector element is very short and entirely intraspinal, its cell being in the posterior horn and its axon arborising around an anterior horn cell. But in the visceral nerves the connector element is longer, starting from a cell in the lateral horn, its axon emerging with the anterior root and going by the white ramus to a sympathetic ganglion. In other words, the whole of the small medullated pre-ganglionic fibre is connector in nature, while the non-medullated post-ganglionic fibre is the effector element. The pre-ganglionic fibre announces its associative connector character, further in the way that it is operative over several effector elements at different levels, as already explained. As Bayliss put it: "Whereas the somatic nerves are formed by *axons* growing out of cells in the central nervous system, the autonomic system is formed by chains of *cells* growing out from the same system and forming axons subsequently."

The purpose of this different arrangement in the two systems is found in the different functions performed by them. The somatic nerves are for localised accurate reflexes, the visceral for wide-spread effects. That is the secret of the arrangement of the sympathetic nervous system. And in this respect we shall find that this system retains a number of primitive features both structural and functional. Thus we have seen that the ganglion cell is primitively peripheral but is withdrawn either into or close to the central nervous system as evolution proceeds. The sympathetic ganglia remain peripheral. Again, the intestinal myenteric plexus which is in close association with the sympathetic nervous system recalls the anatomical arrangement of the primitive nerve net. Yet again, whereas connector neurons ordinarily become strictly confined to the central nervous system, the white rami of the sympathetic which are connectors lie almost entirely outside the central nervous system. As with structure, so with function. There is no discriminative sensibility in the sympathetic, its response is urgent, immediate, widespread and explosive, as are the responses of the primitive nervous system.

So far I have chiefly illustrated my argument from the sympathetic portion of the involuntary nervous system because its segmental arrangement is so much simpler. But we must always remember that it is only one part and not the whole of the involuntary nervous system. Langley introduced the term "autonomic nervous system" for the whole of this, and it is a good name, but unfortunately it has become used in two different senses. The term "vegetative nervous system" has also been suggested and widely adopted. But vegetative hardly seems an appropriate description of the violent, explosive reactions typical of this system. The term "visceral nervous system" seems hardly suitable to include the innervation of such skin structures as sweat glands and hair follicles. So the name selected for this lecture, "involuntary nervous system," seems open to least objection for the whole, "sympathetic" and "parasympathetic" being kept for its two main divisions.

There are certain features of general resemblance between the sympathetic and parasympathetic, with special features correlated with the functions subserved. They both control functions of organic life and act apart from the will. They both arise from corresponding groups of cells in the grey matter with pre-ganglionic elements composed of small medullated connector fibres and conform to the rule that no connector impulse runs direct to muscle or glands but always ends in an arborisation round an effector element in a ganglion. The post-ganglionic non-medullated fibres do not in any case run to other nerve cells of the system, but are distributed to their peripheral destination, branching as they go. But the parasympathetic connector fibres have their cell station close to their destination, so that the effects produced through the post-ganglionic portion are more localised and less widely spread. Except for the pelvic visceral nerve, their segmental arrangement is obscured by the elaboration of the brain. The cranial portion of the parasympathetic sends fibres by the third nerve *via* the ciliary ganglion to constrict the pupil, by the seventh nerve to the chorda tympani *via* Langley's and the sub-lingual ganglia to the submaxillary and sublingual glands, and by the ninth nerve through Jacobson's nerve *via* the otic ganglion to the parotid gland, both of these being secretory in function. But the main cranial parasympathetic nerve is the vagus, which is distributed to the heart and alimentary canal with its outgrowth, *i.e.,* the lungs, liver, gall-bladder and pancreas. The cell stations for the cardiac fibres are in the heart itself, and those for the alimentary tract are found in Auerbach's plexus.

The effects of sympathetic stimulation are all designed to activate the body for a struggle and to increase its powers of defense (Cannon). The pupil dilates to increase the perception of light; the heart beats more quickly and more forcibly to supply the muscles with blood; the blood vessels in the visceral area constrict, raising the blood pressure there, thus altering the distribution of blood and driving it from the digestive area, whose functions are simultaneously inhibited, into the skeletal and cardiac muscles, the lungs and the brain. The blood sugar is increased to supply fuel to the muscles. The sweat glands are stimulated to cool the body heated by its excessive muscular effort, and the hairs are erected in many animals to render them more alarming.

Turning to the effects of parasympathetic stimulation, we find that in general they replace the display of kinetic energy by the storage of potential energy. Cannon says: "A glance at the various functions of the cranial division reveals at once that they serve for bodily conservation: by narrowing the pupil they shield the retina from excessive light, by slowing the heart-rate they give the cardiac muscle longer periods for rest and invigoration; and by providing for the flow of saliva and gastric juice, and by supplying the muscular tone necessary for the contraction of the alimentary canal, they prove fundamentally essential to the processes of proper digestion and absorption, by which energy-yielding material is taken into the body and stored. To the cranial division of the visceral nerves, therefore, belongs the quiet service of building up reserves and fortifying the body against times of need and stress."

The sacral division of the parasympathetic consists of the pelvic visceral nerve. It may be regarded mainly as a mechanism for emptying. "Like the cranial division, the sacral is engaged in internal service to the body, in the performance of acts leading immediately to greater comfort."

Of these two great divisions then, the sympathetic is katabolic, directing the stream of energy outwards, while the parasympathetic is anabolic, directing the stream of energy inwards where it is stored up. When these two are distributed to the same structures their action is always antagonistic, and when one is stimulated the other is inhibited. Anrep has recently shown an interesting exception to the general plan of visceral innervation in the coronary vessels. Here the sympathetic is vaso-dilator while the vagus is constrictor. But this is again an exception which really coöperates with the general scheme. When there is a general vaso-constriction the blood pressure rises and the heart has to do more work, requiring a better blood supply which this special vaso-dilatation provides. Conversely when the vagus inhibits the heart, blood pressure falls and since the heart is doing less work it requires less blood. Simultaneous vaso-constriction through the same nerve prevents a wasteful supply of blood to the heart.

The rhythm of life largely depends on the fluctuating balance between the sympathetic and parasympathetic. Thus fatigue following the expenditure of energy leads to sleep when the parasympathetic gains control, and the arrest of external manifestations of energy lasts until the balance is restored in favour of the sympathetic, when the subject awakens again. The predominance of the parasympathetic in sleep is further shown by the liability for parturition to start and for what one may call parasympathetic accidents to occur during sleep, such as asthma, enuresis and emissions.

We see, therefore, that in pain, fear, rage and any intense excitement the anabolic activities of the body are in abeyance, and the katabolic activities go on unchecked. Potential energy is converted into kinetic, and reserves are freely spent. This is comprehensible since these katabolic activities are defensive in origin and aided the primitive animal in its struggle with its antagonist: and that complex organism, the State, when at war, like the individuals of which it is composed, inhibits its anabolic activities, spends its reserves, and brings into play every katabolic activity which can aid it in its struggle for victory.

It may be asked, how, on this theory, is one to account for the parasympathetic effects that are seen in overwhelming pain or fear—collapse, syncope and loss of sphincter control? Rivers pointed out that a lowly organism has another method of defense—immobility—which takes the form in some animals of "shamming dead." Many animals, although able to perceive a moving object readily, seem to have little appreciation of a stationary one, so that immobility may prevent detection. These two methods of reaction—immobility and preparation for fight or flight—admit of no compromise. One or the other may be effective; to attempt to combine the two would be fatal. The "quoter none" principle is exemplified; either complete immobility through the parasympathetic or violent action through the sympathetic. Thus the confusion is avoided which would inevitably result from simultaneous response of both divisions. If one comes into action the opposing group is inhibited.

Each of these great divisions coöperates with a group of endocrine glands; the sympathetic with the adrenals, thyroid and pituitary, the parasympathetic mainly with the glands of the digestive organs and their annexes, and possibly with the parathyroids. Biologically we may look upon the endocrine glands as a specialisation of the old chemiotactic mechanism of control which is of more primitive origin than the nervous system. But the gonads, which date from the very beginning of the metazoa, also were originally entirely under chemiotactic control. This explains the persistence of the close association between endocrines and gonads, which can be demonstrated both embryologically and functionally. And since the sympathetic nervous system entered into a defensive and offensive alliance with the endocrine glands, a basic tripod came to be formed which was entrusted with the duty both of the preservation of the individual and the continuity of the species. If any one limb of this tripod becomes affected the balance of the whole is disturbed. There is a physiological disturbance of the balance initiated by the gonads at puberty, in pregnancy and at the climacteric, and it is notorious that the sympathetic nervous system may at those epochs experience a difficulty in re-establishing a balance. Pathological disturbances initiated in the same way are also sure to affect the sympathetic nervous system.

But before dealing with these clinical aspects we must briefly refer to the receptor channels of the involuntary nervous system. Although the parasympathetic nerve trunks apparently receive afferent fibres from all the organs to which they send efferent fibres, this is not the case with the sympathetic which receives none from the body walls or limbs, nor from the head where it overlaps the bulbar parasympathetic. It receives relatively few from the region where it overlaps the pelvic visceral nerves.

In the thoracic and abdominal viscera most of the afferent fibres, which on electrical stimulation give rise to pain, pass by the sympathetic and not by the vagus. As already stated, large medullated afferent fibres can be traced from the Pacinian corpuscles in the cat's mesentery. The special features of the afferent nerves to the viscera were summarized by Langley thus:

(1) The healthy viscera give rise to little or no sensation when cut, probably because of the comparatively few sensory fibres in a given area. In pathological conditions, however, cutting may be painful and strong contraction may give rise to intense pain. (2) The localisation of pain is very imperfect. (3) In pathological conditions the viscera readily give rise to pain and tenderness in the body wall.

These points call for further consideration. Although secretory processes and the movements of the gut do not usually pass the threshold of consciousness our internal sensations send impressions to the brain which affect and colour our individuality and we become aware of any great change in them. Hence they may play a part in producing melancholia and hypochondriasis on the negative side or a sense of well-being on the positive side. But the threshold of consciousness is not fixed or invariable. Thus the neurotic learns to speak of his internal sensations with an intimate knowledge to which the normal man is a stranger. Visceral pains can scarcely be conveyed by special nerves, which may never be called into action throughout the life of an individual or the history of a race. It is far more probable, as Foster said, that "the constant smouldering embers of common sensibility may at any moment be fanned into the flame of pain."

Lennander believes that all the pains produced in the abdominal cavity must be referred to the parts, particularly the parietal peritoneum, innervated by the lumbar and sacral somatic nerves. But Hurst points out that this view does not sufficiently take into consideration the fact that an adequate stimulus must be applied. Tension on the muscular fibres of a hollow viscus is the stimulus which it naturally has to encounter, and this stimulus proves adequate to elicit pain. Thus the pain of a gastric ulcer is most probably due to spasm; it is certainly not due to hyperchlorhydria. The agonising pains of hepatic or renal colic, of intestinal or urethral obstruction are examples of increased tension as a cause.

The scantiness of the afferent fibres in the viscera and their defective power of localising internal sensations have an important bearing on referred pain. Head pointed out that, when a painful stimulus is applied to a part of low sensibility in close central connection with a part of much greater sensibility, the pain is referred to the latter rather than to the former, where, however, the stimulus actually arose. The segmental arrangement of the primitive vertebrate still persists in the skin and muscles. Bolk calls the former dermatomes, the latter myotomes, metamerism being more obvious in the dermatomes, the central portions of which correspond with the zones of hyperaesthesia which Head found on the surface of the body in the presence of visceral disease. Head explained this by saying that when abnormal excitations from a diseased internal organ reach the cord by way of its afferent nerves the excitability of its spinal segment becomes enhanced, so that when another cutaneous excitation of low intensity reaches the same segment it provokes pain, whereas under normal conditions it would only arouse a sense of contact. He was also able to demonstrate that the distribution of herpes zoster which is known to be due to an inflammation of one or more posterior root ganglia corresponds to these zones of hyperaesthesia. This fact that internal sensations have a cutaneous representation has provided us with a valuable method of localising visceral disorders as had previously been pointed out by Ross and Sir James Mackenzie.

Time and the necessity of not encroaching on the field of subsequent lecturers prevents my doing more than indicating some of the clinical applications of our knowledge of the involuntary nervous system.

We can hardly speak of organic disease of the sympathetic nervous system, for we have practically no knowledge of its morbid anatomy. Changes have been described in pellagra, but beyond that we can only recognise such things as irritative lesions produced by pressure, and destroying lesions produced by trauma or new growth. In general, therefore, we can only speak of diseased conditions expressing themselves through the involuntary nervous system, without having any clear idea of organic change there. This is in sharp contrast with the fairly accurate knowledge we have of organic disease of the central nervous system and its somatic outflow. We can, however, clearly recognise the part played by the involuntary nervous system in many diseases, both organic and functional.

It is abundantly clear that however the sympathetic nervous system is brought into action it, at any rate, simulates the ordinary expression of certain emotions, and pre-eminently the emotion of fear—palpitations, tachycardia, sweating, blanched extremities, and gastro-intestinal disturbances. It is also clear that psycho-neurotics complain of physical symptoms of this type.

Now psychoneuroses may express themselves at any one of the three great levels of the nervous system; at the psychical level as an obsession; at the sensory-motor level as a paralysis, contracture, tic, or anaesthesia; and at the visceral level as various vegetative neuroses. The shell-shocked soldier may develop a contracture of his arm, the girl exposed to an air raid may develop Graves' disease.

That many psychoneuroses are based on a repressed or subconscious fear is now clearly recognised. Fear, whether of evil spirits, of magic, or of the dark, panic fear dominated primitive man and, whenever our resistance is lowered by disease, by shock or by psychic conflict, we betray our ancestry. That strange primitive being which lurks in the unconscious mind of us all, peeps out.

Without in any way excluding the possibility of structural changes in the sympathetic nervous system, sometimes being responsible for manifestations of its action in disease, we are certainly justified in stating that a state of continued fear, whether recognised or not as such by the sufferer, is capable of producing the symptoms of which they so generally complain. Moreover, I believe that the great majority of such manifestations are of that order.

"Emotion moves us, hence the name," said Sherrington. It would perhaps be more accurate to say that it is designed to move us. When under conditions of modern life emotion is dissociated from the movement it should evoke under more primitive conditions, the sympathetic disturbance may continue. The mobilised army which is not allowed to fight the enemy becomes a danger to its own country. The animal that is restrained from fight or flight suffers from an increased fear.

Nervous impulses tend to run along accustomed channels as Herbert Spencer pointed out. The exciting cause may long have passed from the realm of consciousness but its effects may continue. Designed for an intensive preparation for action or defense the sympathetic response may be dissociated, perverted or prolonged. I may instance Cannon's classical experiment of the effect of suturing the phrenic nerve to the cervical sympathetic in a cat so that at every breath the thyroid gland was stimulated. The gland enlarged on that side and there was unilateral exophthalmos. Prolonged sympathetic stimulation then can enlarge the thyroid. This throws light on the emotional factor, usually a sexual one, in the aetiology of Graves' disease. This prolonged sympathetic irritation may also play a large part in digestive disturbances, for it inhibits gastric peristalsis and produces pyloric spasm.

Hence many cases of so-called "atonic dilatation" of the stomach resolve themselves on analysis to examples of sympathetic inhibition. "Better a dish of herbs where love is than a stalled ox and contention withal" is a saying which has its physiological bearing. Sympathetic irritation by stimulating the mesenteric nerves may inhibit peristalsis and cause symptoms of intestinal stasis. Some of the worst cases of this occur in women who have no employment and no object in life. The acquisition of a definite rationale for existence, whether a happy marriage, an absorbing profession or even a political agitation, may have a remarkable effect on the symptoms of visceroptosis. Again, sympathetic irritation by its vaso-constrictor action may keep the blood pressure at a level which is inappropriate for the task of the heart and the arteries.

We are beginning to work out interesting associations between the nervous and biochemical aspects of this subject, particularly in relation to blood sugar. The thyroid, adrenals and pituitary can each be brought into action through the sympathetic and they each are antagonistic to insulin, raising the level of sugar in the blood. Thus an emotional glycosuria may result, and I am fond of quoting Crile's phrase, "When stocks go down in New York diabetes goes up." On the other hand, the parasympathetic through the vagus can increase the output of enzymes in the external secretion of the pancreas, and it is possible that it can increase the output of insulin also. It has been noted that in asthma, a disease associated with an overacting vagus, the blood sugar tends to be low. That it is not invariably so in the asthmatic paroxysm might easily be due to the counteracting effect of the partial asphyxia on the blood sugar. In hunger pain the blood sugar may be low, and Graham refers that ante-prandial irritability which affects not a few to the same cause. Hector Cameron, struck with resemblance of some of the neurotic outbursts in children subject to ketoses to those seen in children with hypoglycaemia from insulin, thinks that low blood sugar may play a part in the production of neuroses in children. Although the scientific basis for this view has been criticised there is no doubt as to the benefit derived from administration of glucose to such children. After all the craving for sugar and the detestation of fats displayed by many children may have a sound physiological basis.

I should like to put forward the thesis that in many of the diseases I have just referred to, the behaviour of the involuntary nervous system is characterized by dissociation or perseveration. This is a pathological state for a system designed to act as a whole and to act promptly.

Evolved in a subconscious plane, the sympathetic nervous system remains for ever beyond the control of the will. Timme (*Journal of Nervous and Mental Diseases*, 1914, vol. xli, p. 259) quotes an instance which, while apparently contradicting this, proved on further enquiry to support it. This was the case of a man who could voluntarily dilate his pupils, who could cause the pilo-motor muscles to raise the hairs on his arm, and who could at will produce the phenomenon of "goose-flesh" in various parts of his body. When closely questioned, he admitted that the effects were produced not immediately by his will, but always by the intermediation of some association called into being by him. Thus, when dilating his pupils he always imagined himself looking far into space, under which conditions the pupil does dilate. For the goose-flesh effect he would picture to himself his arm plunged into ice-cold water, and the goose-flesh appeared. Various associations produce autonomic effects without our will, and it is reasonable to infer that, if we can recall these associations through our will, the same autonomic effects will be produced.

"Man is not a reasonable creature; he is merely in process of becoming one," says H. G. Wells. Many of our responses are unreasoning. The art of medicine is to come to the aid of such responses by interpreting their meaning. "From the pain of the individual we learn lessons which we apply to the benefit of the community at large."

Sir James Mackenzie neatly defined symptoms as the disturbances of normal reflexes. A normal reflex is certainly purposive and should be painless. Through a chain of conditioned reflexes we associate ideas and achieve consciousness. This consciousness appreciates that a disturbance of the normal reflex is painful, and being still purposive proceeds to investigate the cause of the pain. The dog licks his bite, the burnt child dreads the fire, but from such simple defensive reflexes as these are built up elaborate associations of ideas until in the process of social evolution certain individuals become set apart to be epicritic on other people's protopathic sensations and to try and rectify these disturbed and therefore painful reflexes. There is thus no break in the chain between simple reflexes and the evolution of the medical profession. Behold us, here assembled as the last link in a long chain of conditioned reflexes!

HYSTERIA AS A PRACTICAL PROBLEM *

C. Macfie Campbell

During the past three decades the psychological mechanisms at the basis of hysteria have been studied intensively; the results of these studies have not only revealed the complexity of the underlying forces in hysterical disorders but have thrown a flood of light on psychopathology in general. The subtle psychological formulations of hysteria may leave the average physician somewhat puzzled; in face of the endless ramifications of the subconscious he may hesitate to accept the challenge of the hysterical patient. This would be unfortunate for the hysterical patient comes first of all to the attention of the general practitioner and of the various medical and surgical specialists before he is referred to the psychotherapist. The contact with the specialist has an important influence on the later history of the case, and the ability of the special-

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